§42. Mechanism of Magnetic Axis Sweeping Divertor

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Steady state divertor operations with high performance plasmas have been demonstrated in the LHD. For achieving steady state operation, it is very important to control the deconcentration of divertor heat flux. Slow (period: about 100 seconds) and small periodic sweeping of magnetic axis position achieves the high performance long pulse discharge by overcoming the toroidal nonuniformity of heat load on divertor tiles. The magnetic axis position sweeping was carried out by preprogrammed current control of the poloidal coils. Physical mechanism of the magnetic-axis-sweeping-divertor is studied based on the chaotic nature of lines of force in the peripheral region of plasma column.

The LHD magnetic field is produced with the continuous winding helical coils and without the toroidal coil. Then, a characteristic of the LHD magnetic field is the high magnetic shear configuration in the peripheral region of plasma column including the open field line region outside the last closed flux surface (LCFS) of the LHD. So, lines of force in open field line region show a fractal structure and create a chaotic field line layer. Whisker field lines constitute the divertor field lines in the LHD(Fig.1). It seems that numbers of whiskers and the thickness of each whisker field lines decides the heat flow to the divertor tiles. A slight change in a vertical magnetic field produces slight change in the rotational transform, which greatly changes the alignment of whiskers and the magnetic islands embedded in the chaotic field line region because of the high magnetic shear in the peripheral region. This should be the physical mechanism of the deconcentration of divertor heat flux by magnetic axis sweeping.

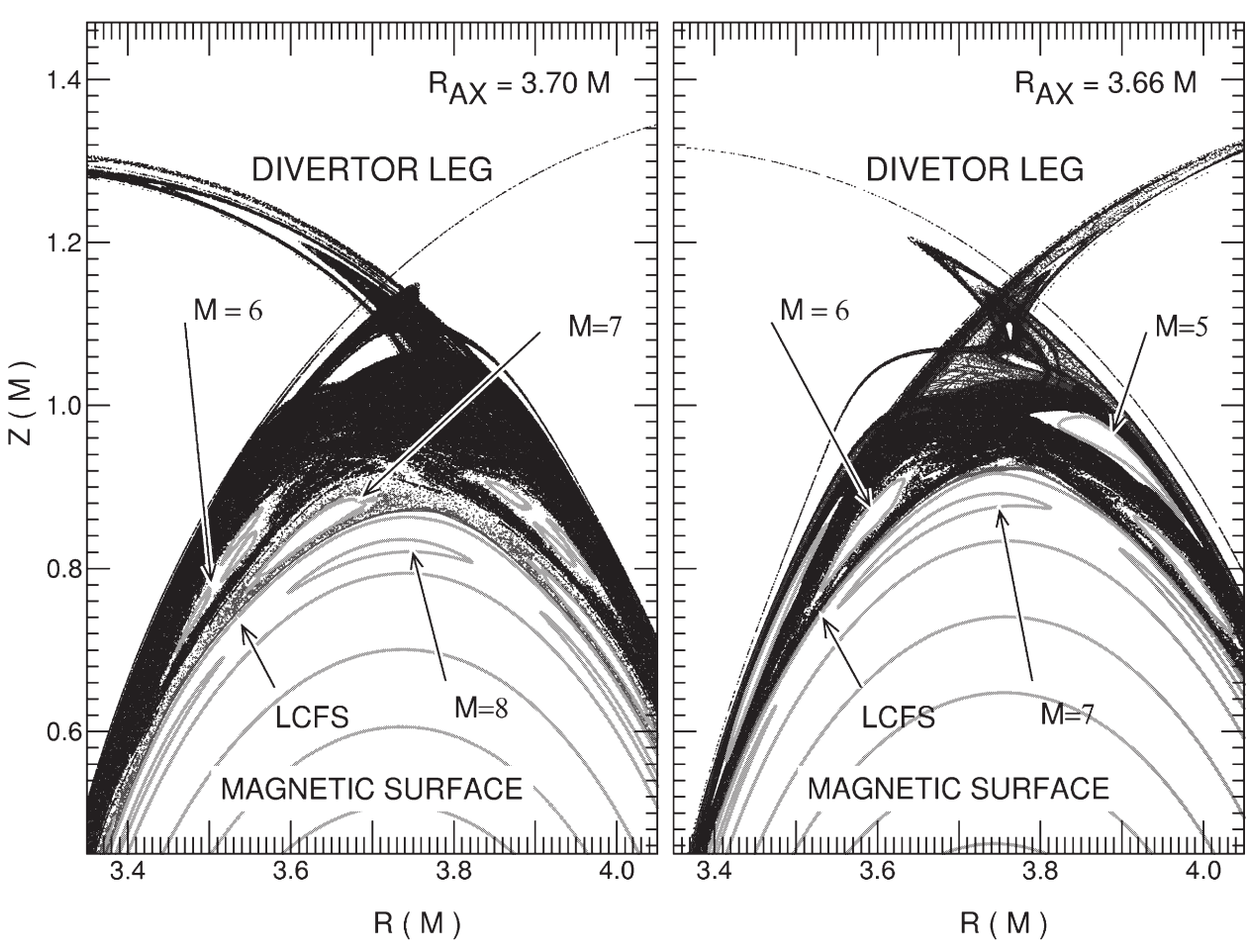

Fig.1. Poincare plot of magnetic field lines in the $\phi = \pi/10$ poloidal cross-section. Difference of divertor field lines (divertor leg) by small difference of magnetic axis position is shown. Magnetic surface region, the LCFS and mode number of relatively large magnetic islands are also specified. The $M = 5$ island disappear and the $M = 7$ island move to the chaotic field line region when $R_{ax} = 3.70\,\mathrm{m}$. R is the major radius and z is the vertical position.